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# NATIONAL PLAN FOR OCEAN SURVEYS

INTERAGENCY COMMITTEE ON OCEANOGRAPHY
of the
FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
United States of America

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ICO Pamphlet No. 7
May 1963

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## FOREWORD

The Interagency Committee on Oceanography, under the direction of the Federal Council for Science and Technology, is responsible for developing annually a National Oceanographic Program to coordinate the efforts of all government agencies in meeting the long-range goals of the United States in marine science. Surveys at sea are an essential part of the national program, and it soon became apparent that there was a need for a unified plan for ocean surveys to provide an efficient means of obtaining the oceanographic data required by many users.

The Ocean Surveys Advisory Panel of the Interagency Committee on Oceanography has prepared this National Plan for Ocean Surveys as a framework within which the specific survey program for each year will be formulated. The plan is a flexible one that will be modified as the requirements for marine data change and as a rapidly advancing technology produces increasingly better means of obtaining these data.

The ICO is grateful to the several non-government scientists who offered advice and assistance in the preparation of this plan.

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# INTRODUCTION

The overall objective of the National Oceanographic Program is the full understanding of the world ocean, its boundaries and its contents, including the physical, biological, chemical, and geological processes associated with it, and the presentation of this understanding in useful form. Acquisition of knowledge about the ocean as a whole is essential to the solution of many of the individual oceanographic problems related to specific aspects of our national welfare.

All of these oceanographic problems are in fact scientific problems; that is, they require new knowledge for their solution. In some cases this knowledge is needed to solve specific applied problems. The detection of submarines, production of coastal and deep sea charts for navigation, safe disposal of radioactive wastes, increasing the commercial fish catch, prediction of sea conditions for the economic routing of ships, and the improvement of weather predictions are examples of such applied oceanographic problems. In some cases the knowledge is needed to solve specific basic research problems such as the understanding of the deep circulation of the ocean, the origin of trenches and seamounts, the dynamic processes that drive the ocean currents, the fertility of the sea, the complex air-sea interaction, and the relationship of marine organisms to their environment. These applied problems and these basic

problems are not mutually exclusive, for work towards the solution of one contributes to the understanding of the other. For the solution of all of this country's oceanographic problems, both applied and basic, there exists an increasing need for oceanographic data.

There are two general approaches to the acquisition of the required data at sea: research and surveys. The research approach entails the collection of data to solve a specific research problem. It is directed towards answering the questions "how" and "why". The surveys approach, on the other hand, is directed towards answering the questions "what", "where", and "when"; it is the larger scale investigation designed to obtain systematic data for multiple purposes over an extended area, entails a larger degree of standardization of techniques, and requires the most accurate of position control. From basic oceanographic surveys will come the base maps of the ocean, will come data necessary for the solution of many of the applied problems of the federal agencies, will come the delineation of areas and features to which the research ships will then return in order to solve new basic research problems which these data have suggested. From these surveys will come systematic data with immediate application to the solution of many existing research problems. The systematic investigation of the world ocean allows for detailed planning in advance so that each trip of each ship contributes a segment to the overall task.

The Interagency Committee on Oceanography of the Federal Council for Science and Technology has, through its Ocean Surveys Advisory Panel, developed the following plan as a framework within which this country will carry out Ocean Surveys. What data are collected is determined by the requirements of the various federal agencies with oceanographic responsibilities and by the various research problems to which Ocean Surveys can contribute. The specific areas for each year's operations will be determined by the overall national requirements, considering both the specific applied objectives and the basic research objectives as modified by the availability of ships, equipment, and navigational control.

## PURPOSE AND OBJECTIVES OF THE PLAN

The National Academy of Sciences Committee on Oceanography (NASCO) summarized the need for the systematic investigation of the world ocean in the following words: "Maps are basic tools for all the sciences that deal with the earth. To understand and use the oceans, we must first map them." Maps of the ocean must show not only the shape of the bottom, but must also show the distribution of the sediments which cover it, the gravitational and magnetic fields, the three-dimensional distribution of physical and chemical properties, living organisms, and such bio-chemical features as the productivity or fertility of the waters. These are the basic data that are needed on an oceanwide basis for understanding the large-scale oceanic interrelationships, and it is only by a program of ocean-wide surveys, carefully planned and skillfully executed, that they can be efficiently provided. Some of the results will be presented as maps, some in tabular form, some as atlases, but all data will be available in usable form to all who have need for this information. The newly formed Intergovernmental Oceanographic Commission early realized that the systematic investigation of the world ocean was a problem of prime importance that necessitated a coordinated international approach. That organization has already taken steps to establish the "general scientific framework" for such an international effort, and the United States Ocean Survey Plan will contribute to this

international endeavor.

The primary objective of the Ocean Survey Plan can be simply stated: to provide for the efficient and systematic collection, compilation, and presentation of oceanographic data for use in furthering our understanding of the sea for science, for the national economy, and for defense. More specifically, there are certain missions of the Federal agencies which are dependent for their efficient prosecution upon systematic ocean surveys, and there are basic scientific problems of world-wide scope which also require surveys of this nature to provide the data necessary for their solution. The Ocean Survey Plan has been devised in response to these applied and basic data requirements so that each ship or other data-collecting means will be utilized to the fullest in the making of observations and collections at sea. The specific objectives for which this Plan was developed include:

1. The Navy has urgent requirements for ocean-wide data on bottom topography, gravity, magnetics, sediment characteristics, and the varying characteristics of the water column. The requirements are related to the installation and maintenance of ASW systems, prediction of sonar ranges, effective routing of ships, mine and counter-mine operations, surface and sub-surface navigation, the operation of specific weapons systems, and pro- and anti-submarine warfare operations. Time-series and synoptic surveys are required to assist in obtaining the required understanding of the ocean as an operational environment. If the Navy is to operate in all

parts of the sea with equal effectiveness, it must have the ocean-wide data which the Ocean Surveys Plan is designed to provide.

2. The Coast and Geodetic Survey is charged with the gathering and dissemination of knowledge in the form of publications and charts on bottom topography, currents, tides, and certain geophysical aspects of the sea. This agency, through concerted Ocean Surveys, will be better able to fulfill these responsibilities. The resulting data will be used as charts for navigation and as basic (background) surveys for the future development and utilization of the sea as a natural resource. Improved current charts and wave forecasting techniques will promote economic growth by allowing goods to be transported faster - and therefore more cheaply - to foreign markets. The surveys are also important to the geodetic program of the Coast and Geodetic Survey through the providing of gravity data taken at sea. Since the shape of the earth can be determined from a complete picture of the gravity field, it is essential that the distribution of the gravity field at sea be known. The gravity data are needed not only for positioning remote islands, but also for predicting perturbations in satellite orbits and the effects of the earth's gravity field on manned space travel.

3. The Weather Bureau and military weather services have pressing requirements for the improved forecasting that will come from a thorough understanding of the air-sea interaction.

This is particularly true of long-range weather forecasting for which a vastly augmented program of surface and upper air observations as well as surface oceanographic observations is essential. The meteorological portion of the Ocean Survey Plan has been designed not only to provide the Weather Bureau with meteorological data required from their "scarce data areas", but also to provide the means for collecting simultaneous oceanographic and meteorological data from ships and instrumented buoys on a world-wide scale for use in understanding air-sea interaction. This understanding is essential to the development of long-range weather forecasting and the possible eventual modification of our climate and weather.

4. The Geological Survey and the Bureau of Mines are responsible for investigations of the geology and mineral resources of the oceans. The Ocean Survey Plan includes their requirements for many kinds of geophysical data and for the systematic sampling of the sea floor at oceanographic stations in order to pinpoint areas of scientific and economic interest. Results of the investigations will provide information that is needed for an understanding of the oil and water-bearing sedimentary rocks that are now on land but originally formed in the marine environment, of geologic structures that control the distribution of mineral and water resources both on land and beneath the ocean, and of new sources of strategic minerals that may be acquired from the ocean and from the sea floor.

5. The Bureau of Commercial Fisheries is responsible for the management and wise utilization of the commercially valuable living resources of the sea. Towards this end, the biological collections and measurements to be carried out as part of Ocean Surveys have been planned to provide the needed information on the distribution and abundance of the living creatures in the sea. The collections of physical and chemical data together with the biological data are designed to provide information needed in understanding the relation of the living population to its physical-chemical environment, an important aspect in the prediction of where commercially profitable stocks may be found.

6. The Bureau of Sport Fisheries and Wildlife is concerned with the recreationally valuable living marine resources. Ocean Surveys, particularly that portion covering the Continental Shelf, will provide essential information on the distribution of such organisms and the physical and chemical characteristics of this environment.

7. The Coast Guard has certain oceanographic responsibilities to which the Ocean Survey Plan is responsive. These include the U. S. portion of the International Ice Patrol, the Bering Sea Patrol, and the Coast Guard's Polar Operations, all of which will benefit from the concerted Ocean Survey effort.

8. The Smithsonian Institution's traditional interest in the taxonomy and distribution of marine organisms arises from its broad statutory responsibilities for the stimulation and diffusion of knowledge. The biological portion of the Ocean Survey Plan has been made responsive to this interest and will work closely with the Smithsonian's biological sorting center.

9. The Atomic Energy Commission and the Public Health Service are both concerned with the distribution and effects of radioactivity and other marine pollutants. The programs of these two agencies will utilize not only the ocean current data but also the results of the radioactivity sampling at oceanographic stations within the Ocean Survey Plan.

10. The Beach Erosion Board of the Army Corps of Engineers will utilize data from the shelf portions of Ocean Surveys in their studies of coastal erosion and in locating offshore sand bodies for beach replenishment, and the Maritime Administration will utilize wave data in their program for improved ship design.

11. Ocean Surveys will provide data for use in basic oceanographic research studies. In particular, the large-scale scientific problems of the sea need large volumes of survey data for their solution, and it is toward the providing of these data that the Ocean Survey Plan is also directed. The understanding of the large-scale dynamic processes affecting the distribution of the physical and chemical properties of

the sea requires that these distributions first be described on an ocean-wide scale as planned by Ocean Surveys. Complete knowledge of the complex interactions between the sea and the atmosphere will be gained only after the pertinent oceanographic and meteorological data have been obtained. The understanding of the interrelationships of marine organisms to each other and to the physical and chemical properties of the marine environment depends upon the availability of information on the distribution of the organisms and of the pertinent properties. The understanding of the geological, geochemical, and geophysical nature of the sea floor necessitates that additional data in these fields be obtained. The Ocean Survey Plan cannot of itself solve these basic scientific problems, but through careful planning in conjunction with the non-governmental scientific community these surveys can provide the maximum scientific information to the basic research scientist, information that is absolutely essential to his solution of these problems.

12. Finally there is the totally unpredictable discovery of new basic concepts that will inevitably come from the accumulation of data produced by an accurate and thorough program of Ocean Surveys.

In addition to providing the framework within which these objectives can be attained, the Ocean Survey Plan will also provide for the following:

1. Publication of results
2. Standardization of data-reporting on forms provided by

the National Oceanographic Data Center to insure that the data will be presented in a form for ready processing and dissemination. NODC is charged with the acquisition, processing, and dissemination of oceanographic data, and it is through this center that the data from Ocean Surveys will be made available to all.

3. Support and encouragement of international cooperation in these investigations through the Intergovernmental Oceanographic Commission.

4. Encouragement of research and development of improved instruments and automatic data handling techniques for more efficient accomplishment of the plan.

5. Initiation of a continuing operations analysis study to provide additional information for insuring that the most economical and efficient means are employed to obtain the data and that the program is appropriately modified as the accumulating data and advances in technology make such modifications desirable.

6. Continuing evaluation of the program in terms of ships, facilities, and manpower required. This will be accomplished not only in the light of what needs to be done in Ocean Surveys, but also within the framework of the required overall national balance of support for surveys, research, facilities, ship construction, and the various other aspects of the continuing National Oceanographic Program.

## THE OCEAN SURVEY PLAN

### A. Scope and Orientation

This Ocean Survey Plan is to serve as the general framework within which each year's Ocean Surveys will be planned. Although the data requirements of various research problems will be considered in the formulation of the annual operational program, this is strictly a survey effort. That is, it is aimed directly at insuring systematic areal coverage with accurate navigational control, and it will incorporate the acquisition of as many different types of data as is possible from the platforms being used. Within the limits of practicality, the data acquisition and processing will be standardized to the extent that data taken by a variety of ships and buoys at different times and in different areas will be compatible and can be easily combined with other similar data in the presentation of results. Through the mechanism of an annual planning and review conference, each year's program will be responsive to the current requirements for oceanographic data and will be modified as new needs arise and as new instruments and techniques become available.

### B. Program Planning and Operations

The operational responsibility for Ocean Surveys rests primarily in the various Federal agencies which will be carrying out the major portion of the operations at sea. Planning coordination, however, will be effected by the

Ocean Surveys Advisory Panel of the Interagency Committee on Oceanography. On this panel are representatives of each of the agencies involved as well as a representative of the non-governmental scientific community appointed by the National Academy of Sciences Committee on Oceanography. Cooperation with the Interagency Committee on Atmospheric Sciences insures the consideration of their requirements in survey planning.

The importance and magnitude of the Ocean Surveys Program necessitate that is be planned and conducted with the advice and assistance of the most competent scientists both within and outside of the Federal Government. For this reason, there will be an annual planning and review conference at which the Ocean Surveys Advisory Panel will meet with a group of non-government scientists who are actively engaged in work in the various fields of marine science. This conference will review the results of the previous year's survey operations and will advise on the planning for the coming year. These conferences and the continued informal contacts with the non-governmental scientific community will insure that Ocean Surveys are providing the maximum amount of useful scientific data required to satisfy the needs of all users.

In order that the Ocean Surveys portion of the overall National Oceanographic Program remain in proper balance with the other oceanographic activities, there will continue to be careful scrutiny of this aspect as well as of the other parts of the program to insure overall program balance. This program review is carried out annually be the Interagency

Committee on Oceanography in preparing programs and budgets for the next fiscal year, and a further review is provided by an Ad Hoc Panel appointed annually by the Office of Science and Technology.

C. Areas for Investigation

It is hoped that eventually the entire ocean will be covered with oceanographic surveys. This will necessitate that the Ocean Survey effort become a cooperative international program if this aim is to be realized in an efficient and timely manner. Until such international plans have been formulated and agreed upon, the specific areas for the United States effort must reflect the most urgent needs of the United States.

Oceanographers are interested in a variety of scientific problems and in various portions of the ocean. For this reason, there is a variety of opinion as to what portions should be investigated first to collect data needed for the solution of basic research problems. Similarly, the various Federal agencies have requirements for data from various parts of the world ocean. Thus, to date, the decision as to location of the surveys has been made by the only agency which has a ship operating exclusively on this program. This decision was made on the basis of where adequate navigational control was available within the various areas in which there was broad oceanographic interest. Once the area had been decided upon, the various participating agencies and private oceanographic institutions were asked what interests they had within this area that could be advanced

by data obtained during these surveys and were provided the opportunity to place personnel and equipment aboard.

As the program advances and more ships are available for Ocean Surveys, and as accurate navigational control everywhere at sea becomes a reality, then the areas of Ocean Survey operations will become more truly responsive to the overall national need. Once this stage has been reached, then the choice of areas for each year's survey operations will be determined jointly by the Ocean Surveys Advisory Panel in consultation with qualified representatives of the non-governmental scientific community. Until then, however, the choice of areas for Ocean Surveys must be based primarily on the availability of adequate navigational control, ships, and effective logistic support.

D. Platforms to be utilized in Ocean Surveys

The majority of the Ocean Survey work at sea will, at least for the next ten years, be carried out from ships. During this period, it is envisioned that a network of recording or telemetering oceanographic buoys will become established which will provide time-series and synoptic oceanographic and meteorological data currently planned for collection by Ocean Survey ships. With the advent of such an operational buoy system, the oceanographic station operations of the survey ships will be modified accordingly, allowing more ship-time for the underway portions of the program. Similarly, as offshore platforms,

aircraft, satellites, and newly developed automatic data collection devices are able to contribute to the acquisition of the desired data, these techniques will be phased into the plan with accompanying adjustments in the missions of the ships. The best estimates presently available, however, indicate that ships will remain the major operational element in the program through at least 1972. These ships will include:

1. Present survey ships of the Naval Oceanographic Office and the Coast and Geodetic Survey,
2. Newly constructed oceanographic survey ships currently planned by government agencies,
3. Bureau of Commercial Fisheries ships,
4. Coast Guard ships, and
5. Oceanographic research ships of the military and civilian oceanographic laboratories whenever these laboratories feel that participation in a specific survey will further their research aims.

An essential element of the Ocean Survey Plan is that each platform be utilized to the utmost. For the ships this means that any that are used for Ocean Surveys will collect as many of the prescribed data as their instrumentation and capability permit, even though the agency operating the ship does not itself have a specific requirement for some of these data. Personnel on Ocean Survey ships of the Coast and Geodetic Survey and of the Coast Guard will thus obtain biological specimens and data and meteorological information

for the use of other agencies such as the Bureau of Commercial Fisheries and the Weather Bureau. When necessary, personnel from the pertinent agency will be aboard to collect such data. Similarly, the vessels of the Bureau of Commercial Fisheries operating on Ocean Surveys will, whenever possible, collect magnetic, bathymetric, and meteorological data for transmission to the appropriate agency for processing although these are not required for their own specific needs in the field of living marine resources. The data requirements of each agency will be channeled through the Ocean Surveys Advisory Panel for inclusion in the annual survey program. Thus maximum utilization of all vessels will insure maximum efficiency in obtaining the many various types of oceanographic data that are needed.

E. Instrumentation

The efficiency and effectiveness of Ocean Surveys depend to a considerable degree on the instruments and instrument systems available. New instruments and techniques must be developed through a continuing effort to upgrade the quality and efficiency of the observations. The problems associated with the sustained collection of large quantities of environmental data must be resolved, and the latest techniques must be exploited in the processing, reduction, storage, and dissemination of the data collected. Towards this end, an operations analysis will be undertaken to provide

information on which the program can be modified and upgraded to take advantage of new knowledge and technological advances as they become available.

However, the urgent need for data from the world ocean does not allow postponement of the initiation of the program until specific instruments and systems under development are actually in hand. Thus, cruises within the Ocean Surveys Plan have been started using existing instruments and will continue to use them until better ones have been developed, tested, and found to be superior to those currently in use.

Instrument test and calibration are especially important aspects of Ocean Surveys where many ships and - eventually - buoys will be collecting similar types of data which must be mutually compatible. An instrument test and calibration center, established by the Naval Oceanographic Office but available to other agencies, is in operation. Through this center and others which may be established, instruments and other equipment used in Ocean Surveys will be calibrated and tested.

Intercalibration or standardization of observational and analytical techniques is an additional aspect which requires attention. Under the auspices of the National Academy of Sciences Committee on Oceanography, the equipment and techniques used by various government agencies and private institutions for the Winkler method of determining dissolved oxygen concentration in sea water have been examined with a view toward intercalibration. A similar evaluation of

various types of salinity bridge has been carried out by the Naval Oceanographic Office. Not only will Ocean Surveys take advantage of the results of such tests, but through the ICO Ocean Surveys Advisory Panel and the various participating agencies other comparable intercalibrations will be carried out to insure compatibility of results. These efforts will of necessity be coordinated with international tests designed to insure the same results on an international basis.

F. Navigation

For an effective program of Ocean Surveys, the availability of an accurate means of positioning a ship anywhere at sea is a basic prerequisite. Samples and measurements taken at sea are only of limited value without accurate knowledge of the location at which they were obtained.

In the past, considerable oceanographic work has been accomplished using the time-honored but relatively inaccurate techniques of celestial navigation and dead reckoning. For some operations at sea, particularly measurements of those factors that vary so rapidly with time that their absolute geographic position is relatively unimportant, these methods have been adequate. However, for accurate mapping, particularly of those time-independent variables such as bottom topography, sediment distribution, and spatial variations in the gravity and magnetic fields, accurate position control is absolutely essential.

For Ocean Surveys, the following navigational criteria have been developed:

(1) The system must cover the world ocean in its entirety; however, all areas need not be covered at the outset of the program.

(2) Two basic systems are needed to cover all types of oceanographic operations: a short-range system with accuracies of $\pm$ 100 feet at a maximum range of 200 miles from shore, and a long-range system covering the rest of the ocean with an accuracy of $\pm \frac{1}{2}$ mile.

(3) The shipboard equipment must be suitable to installation on a variety of ships, must have a high reliability, be easily operated and maintained, be relatively light-weight and compact for installation on all ships engaged in Ocean Surveys, and must be suited to easy dismantling, removal, and relocation on another vessel.

(4) The shore installation must have an on-the-air time in excess of 95 per cent, the signals must be free of ambiguity, and the system must be capable of simultaneous use by many ships.

(5) Neither the operation of the system (from land stations or from satellites) nor the shipboard equipment should be so expensive that sheer cost alone precludes its use by all ships operating on Ocean Surveys.

The various systems currently available or in the development stage have been investigated and evaluated from the viewpoint of Ocean Surveys. For use within 200 miles of land, several commercial systems are available which meet the above criteria, and various of these are already in use by the Coast and Geodetic Survey, the Coast Guard, and the Navy. It is not within the limits of this plan to recommend one over the other, merely to prescribe that any system used meet the requirements outlined above.

No present system meets all the requirements for the long-range coverage. Loran-C meets most of them, but the coverage is limited. In those areas where the system is operational, it is adequate for Ocean Surveys. The radio sextant will provide ocean-wide coverage, but it is expensive, entails complex equipment, and provides positional accuracy of only about $\pm$ 2 nautical miles. Probably the navigational satellite system offers the best practical solution to the navigational problem. It will, when fully operational, provide ocean-wide coverage within the accuracy limits desired, will be within a reasonable price range for the shipboard equipment, and will meet satisfactorily the other requirements listed above. The Navy and the Coast and Geodetic Survey have already made plans to obtain early models of the required shipboard equipment for evaluation when the system is operational. Only the OMEGA system, currently in the research and development stage, competes with

satellite navigation as a possible system for adequate navigational control for Ocean Surveys. The development of both of these systems will be followed closely.

Until these systems are operational, Ocean Survey ships will depend for position control primarily on Loran-C with back-up by such conventional systems as Loran-A, the sextant, and dead-reckoning.

G. Types of Investigation

Investigations are categorized by the spacing of ships' tracklines and the frequency of data collection. Four basic types are included in the Ocean Surveys Plan: exploratory, developmental, time-series, and synoptic. These surveys are also divided according to the method of ship operation into underway operations and oceanographic station operations.

Exploratory surveys are those conducted to develop the gross features and general conditions in an area where little data are available.

Developmental surveys are those conducted to determine the detailed features and environmental conditions in an area where enough previous data exist to plan such a survey intelligently.

Time-series surveys are those in which a ship or an instrumented buoy remains in one place making repeated observations of those factors that vary with time.

Synoptic surveys are those that obtain simultaneous observations and measurements of the time-dependent variables

from many locations within a given area. This may be accomplished by the simultaneous occupation of oceanographic stations by many ships or by the utilization of a network of fixed or drifting instrumented buoys positioned within the area.

During the early stages of Ocean Survey operations, the major effort will be devoted to the exploratory and developmental type of investigation while at the same time pressing for the development of the oceanographic buoy systems that will provide the most economic means of carrying out both the time-series and synoptic types of surveys.

Similarly, the underway type of survey will receive the major emphasis in the early stages of the Ocean Survey Program. These surveys will ideally include continuous measurement of the water depth with precision echo sounders to depict sea floor topography, gravity measurements to develop the distribution of the earth's gravity field at sea, magnetic measurements to develop the distribution of the intensity of the earth's magnetic field, seismic measurements to determine the sub-bottom structure, regular measurements of key variables at the air-sea interface and meteorological measurements of the upper air characteristics, measurements of the physical, chemical, and biological factors of the upper layers of the sea that can be measured from a ship under way, and continual visual observations of sea surface and atmospheric phenomena.

The line spacing for surveys of this nature will be determined on the basis of the data already available from the area, the desired intensity of coverage for various types of data, the environmental complexity of the area, the adequacy of available navigational control, and such other factors as distance of the area from the operating bases of the ships, expected weather and sea conditions, and the availability of equipment to make all the basic underway measurements listed above.

Oceanographic station observations, on the other hand, are those in which the ship is required to stop in order to make the observations. As in the underway operations, the spacing of observations will vary with the area under investigation. Oceanographic station observations will ideally include measurement and sampling of the physical, chemical, biological, and geological properties of the entire water column and the ocean floor and measurement of the meteorological characteristics of the overlying atmosphere.

In the early stages of Ocean Surveys, both underway operations and oceanographic station operations were carried out from the same ship but at different times during the field season. As the Ocean Surveys progress, it will probably be found expedient to have some ships carry out underway operations as their primary task, while other ships will be assigned primary responsibility for oceanographic station operations. The division of ship tasks is one facet of the Ocean Survey Plan to which operational analysis will be directed.

H. Oceanographic Data to be collected

The basic data to be collected are listed in Appendix I. These generally will include: (1) measurement of the physical and chemical properties of sea water, (2) bathymetric and other geophysical measurements, (3) measurements of water motion, (4) biological collections and measurements, (5) geological samples, and (6) meteorological measurements. Other types of data may be added to the program as the need for them arises, and special observations may be added at any time. The annual operational program is sufficiently flexible that such modifications can easily be accommodated.

I. Data Processing

Each agency or institution participating in Ocean Surveys with ships or personnel is responsible for the scientific accuracy of its samples and observations and for their laboratory analysis and reduction. Each is also responsible for insuring that its data are transferred to the holdings of the National Oceanographic Data Center. Standardized reporting forms are available from NODC and will be used in forwarding Ocean Survey data to that organization. Where samples or observations are taken for an organization other than the one operating the collecting platform, these data will be forwarded to the responsible agency for processing and transfer to NODC.

J. Publication of Data

Each participating agency or instituion will be responsible for publication of its own data. In some cases this may take the form of a cruise report which contains tabulations

and charts of all the data obtained during a particular field season. In other cases the publication may concern itself with only one type of data that was collected from various ships over a large area or over a relatively long period of time. In any case, copies of all data are to be made available as soon as possible to the National Oceanographic Data Center so that they will be readily available through that organization to potential users.

Because many agencies and institutions will use the amassed data, the ICO Ocean Surveys Advisory Panel in consultation with the National Oceanographic Data Center and the non-governmental oceanographic community will resolve such publication problems as the standardization of the format and content of atlases, and the scale, projection, and content of bathymetric charts and of maps showing the distribution of variables. Professional papers on the results of research carried out using the data from Ocean Surveys shall, of course, be published in any way that meets the research scientist's requirements.

When the data have accumulated to the extent that considerable information is available for a large segment of the ocean, the separate cruise reports and data reports will be used as the basis for publishing an atlas of the results of the surveys of that particular area.

K. Shore Facilities and Manpower

The steadily increasing amounts of data and volume of samples resulting from these surveys will require augmentation of shore facilities and manpower to process and analyze

them within a reasonable length of time. The detailed planning for such facilities and personnel is not within the scope of this plan, but it is important that the agencies involved be aware of this increasing demand. Their needs for space and scientific and technical personnel related to Ocean Surveys can be fairly accurately gauged by the rate at which new ships and instrumented buoys or other data-accumulation methods are added to the program. Since there may be a lag of three or more years between the time funds for new ships or buoys are budgeted and the time these will be providing a steady flow of oceanographic data and samples, adequate time is available to provide for the facilities and manpower to handle the information from these new sources. The ICO through its Panel on Facilities and Instrumentation and its Panel on Manpower and Education will take these increasing demands into account during annual reviews of the National Oceanographic Program.

L. Ships required

It might appear almost axiomatic that as more properly staffed and instrumented ships are available, the greater will be the rate at which the ship-portion of the program can be prosecuted. However, there are certain factors that limit the rate at which new ships can or should be added to the small existing oceanographic survey fleet. These limiting factors include (1) availability of funds for new ship construction, (2) maximum rate at which new personnel can be brought into the field and trained, (3) the phasing of ship

construction plans in order to incorporate new ideas and new equipment in future oceanographic survey ships, (4) the presently unknown rate at which ships of other countries will be assigned to ocean surveys means that the total magnitude of the eventual United States effort is still unknown, and (5) the operational costs of these ships which will continue throughout their useful life. Only by proceeding with a reasonable program of new ship construction can we avoid the wasteful extravagance of a crash program. Only by evaluating the contribution of the first few Ocean Survey ships can we properly verify the validity of the present plans for additional ship construction.

The proposed schedule for new ship construction for Ocean Surveys is given in Appendix II. This schedule has been developed by considering the urgent need for oceanographic data within the framework of the limitations listed above. It is a conservative schedule, based on the best estimates available at this time. It is also a flexible schedule and can be revised either up or down as requirements, conditions, and new techniques may demand. This is one more aspect of the Ocean Surveys Plan that will be considered during the planned operations analysis program.

Although for planning purposes it would be helpful to state that the overall task of Ocean Surveys has certain finite dimensions, and once it is done it is done for ever; this is not the case. The history of mapping and charting is one of returning to the same area to obtain greater detail, or to collect new information made available by

technological developments. In all probability the job of surveying our oceans will never be completely done. Just as the job of mapping our land areas continues as needs for more information arise, so the job of obtaining oceanographic data will continue. The point to be made, however, is that the Ocean Survey Plan is a start on a tremendous job. It is an effort to provide for the systematic and efficient collection of data at sea in response to the current demands for these data. The plan is flexible. As the demands change the plan will change to reflect these demands.

Even though Ocean Surveys will be a continuing effort, some of the alternatives available in terms of numbers of ships and the amount of work they might accomplish on underway surveys within various finite periods of time are presented in Appendix III.

M. International Cooperation

Although this plan is designed as a guide for the prosecution of systematic Ocean Surveys by the United States to meet this country's demands for accurate oceanographic data on a world-wide scale, the magnitude of the task obviously precludes any realization of world-wide coverage of meaningful data by a single nation within any reasonable period of time. For this reason, close international cooperation in furthering oceanographic surveys of the world ocean is an absolute necessity.

A preliminary version of this plan was presented by the United States at the First Session of the Intergovernmental Oceanographic Commission in Paris in October 1961. Intergovernmental working groups met during 1962 to work out details of the International Indian Ocean Expedition and the International Cooperative Investigations of the Tropical Atlantic. Other intergovernmental groups meeting under the aegis of the IOC addressed themselves to such relevant problems as fixed oceanographic stations (i.e., instrumented oceanographic buoys, ocean station vessels, offshore platforms, etc.) and the communications requirements of oceanography. At the Second Session of the ICO in September of 1962, the need for cooperative surveys of the world ocean was reaffirmed and a mechanism was set up whereby the "general scientific framework" for such surveys would be established. These meetings of the IOC and its various working groups are the necessary preliminaries to establishing an international cooperative investigation of the ocean on a world-wide scale. Through the IOC the mechanism exists whereby such a cooperative international investigation of the world ocean will eventually come into being.

However, the United States must not delay its own survey program until such an intergovernmental plan is developed. The U. S. will, on the other hand, modify its own program as necessary to take into account any commitments made by the Government in support of the international effort to achieve these same goals.

In the meantime, the Intergovernmental Oceanographic Commission is being kept apprised of the progress of the U. S. surveys, and the United States has already declared this program to be one from which data will be made available for international exchange. Through the IOC, the United States has urged that other countries join us in carrying out these surveys, and plans are now being formulated for U. S.-Japanese cooperation on Ocean Surveys in the North Pacific. The Ocean Surveys Advisory Panel of the ICO will continue to press for international cooperation in this endeavor through the Panel's contribution to the backup material for and membership on U. S. Delegations to the Intergovernmental Oceanographic Commission.

International cooperation is essential if the data for understanding the ocean are to be obtained efficiently. In addition, the by-products of this cooperation will include international standardization of analytical techniques, units of measurement, and measuring instruments. The United States through this cooperation will also have an opportunity to use Ocean Surveys as a means of assisting other countries in the expansion of their oceanographic and fisheries capabilities.

For long-range planning purposes, it is being assumed that the United States portion in any eventual cooperative international program of Ocean Surveys will be about 30 per cent, the amount comparable to our financial contribution to the United Nations and its various specialized agencies.

# APPENDIX I

## OCEANOGRAPHIC DATA TO BE COLLECTED ON OCEAN SURVEYS

Obviously it will not be possible to have every ship engaged in Ocean Surveys make all the various types of observations and measurements and collect all the various types of samples desired. There will be equipment limitations, and some ships will be carrying out primarily underway operations, whereas others will be equipped specifically for oceanographic station operations. In some cases, certain types of information may already be available from the survey area. In other cases desired sample spacing will limit observations to selected stations or to only portions of underway lines. However, each ship, buoy, etc. will collect as much information as is practical.

The following list of desirable data reflects the current need for oceanographic information to aid in the solution of specific applied oceanographic problems and certain basic research problems which are ocean-wide in scope. The list, of necessity, also reflects the present availability of instruments and equipment. As new and improved instrumentation becomes available, the list will be modified accordingly. No limit is placed on the types of data that can be acquired by Ocean Survey ships. Rather, the following list represents those types of data that should be obtained on an ocean-wide basis during the course of an Ocean Surveys program. The list

is further limited to those types of data that can be obtained during exploratory and developmental surveys of the underway type and of the oceanographic station type. Similar tabulations for the synoptic surveys and the time-series surveys are not given, because surveys of these types must be more specifically tailored to the particular problem for which the data are required.

A. Measurements of the Physical and Chemical Properties of Sea Water.

1. Temperature vs depth to 900 feet (BT) - underway and at oceanographic stations.
2. Temperature vs depth to bottom - at oceanographic stations.
3. Continuous sea-surface temperature - underway and at oceanographic stations.
4. Nansen casts (or other water sampling methods) for salinity, dissolved oxygen, nutrients, and other chemical determinations - at oceanographic stations.
5. Sound velocity (direct measurement) - at oceanographic stations.
6. Samples for analysis of radioactivity - at oceanographic stations.
7. Hydro-optical measurements - at oceanographic stations.

B. Geophysical Measurements

1. Gravity - underway and at oceanographic stations.
2. Magnetism - underway and at oceanographic stations.
3. Sub-bottom structure profiles - underway.
4. Refraction seismology - at oceanographic stations.

C. Geological Measurements and Collections

1. Continuous hydrography (sonic soundings) - underway.

2. Bottom samples (core, dredge, etc.) - at oceanographic stations.

3. Bottom photography - at oceanographic stations.

D. Biological Collections, Measurements, and Observations

1. Water samples for basic productivity and plant pigments - underway and at oceanographic stations.

2. Quantitative phytoplankton and zooplankton collections - at oceanographic stations and underway using high-speed sampling devices.

3. Collections of larger invertebrates, fish juveniles and adults (mid-water trawls, night lights, etc.) - at oceanographic stations.

4. Standardized observation and reporting of sightings of fish schools, sea birds, and aquatic mammals - underway and at oceanographic stations.

5. Routine reporting of other natural and unusual phenomena (discolored water, mass mortalities, aggregation of organisms in relation to oceanic fronts or current boundaries, etc.) - underway and at oceanographic stations.

6. Bottom samples for collection of benthonic organisms - at oceanographic stations.

7. Observations of the deep-scattering layer (by fully annotated echo sounder records) - underway.

E. Water Motion Measurements

1. Direct measurement of surface currents (GEK, drogues, etc.) - underway and at oceanographic stations.

2. Direct measurement of subsurface currents - at oceanographic stations.

3. Wave height, direction, and period - underway and at oceanographic stations.

F. Meteorological Measurements

1. Incident and reflected radiation - underway and at oceanographic stations.

2. Local weather observations - underway and at oceanographic stations.

3. Upper-air measurements - underway and at oceanographic stations.

# APPENDIX II

## TENTATIVE SCHEDULE FOR NEW SHIP CONSTRUCTION

## for OCEAN SURVEYS

| | FY-1962 | FY-1963 | FY-1964 |
|---|---|---|---|
| Navy | ----- | 1(2550-T)[1] | 1(2550-T)[2] |
| C&GS | 1(3800-T)[1] | 1(3800-T)[1] | -------- |

| | FY-1965 | FY-1966 | FY-1967 |
|---|---|---|---|
| Navy | 1(2550-T)[2] | ----- | 1(2550-T) |
| C&GS | 2(3800-T) | 1(3800-T) | 1(3800-T) |
| | | 1(1600-T) | 1(760-T) |

| | | |
|---|---|---|
| Totals: | 1962 - 1 | 1965 - 3 |
| | 1963 - 2 | 1966 - 2 |
| | 1964 - 1 | 1967 - 3 |

Total of 12 new oceanographic ships built or under construction by FY-1967.

1/ These ships are funded and are under construction

2/ These ships will probably operate half time on special military projects.

## APPENDIX III

## MATRIX SHOWING RELATIONSHIP OF NUMBERS OF OCEAN SURVEY SHIPS TO THE ANTICIPATED WORK THEY CAN ACCOMPLISH UNDERWAY WITHIN VARIOUS FINITE PERIODS OF TIME.

The matrix which follows has been developed to give some idea of the amount of underway oceanographic survey operations that might be accomplished with various numbers of ships working for various finite periods of time.

The following assumptions have been made in arriving at these estimates:

1. The ocean area of 104,817,800 square nautical miles is represented by a square, 10,238 nautical miles on a side.
2. All ships operate at sea 240 days per year.
3. All ships steam continuously at an average speed of 10 knots.
4. Ten per cent of the work of each ship is devoted to running crosslines. These are not included in the figures given.
5. Oceanographic station operations will not be carried out by these ships.

The upper number in each block of the matrix indicates how many linear nautical miles of survey will have been run by the end of the year shown at the left margin using the total number of ships shown at the top. Similarly, the lower number in each block indicates the spacing (in nautical miles)

between survey lines that would result if this effort were distributed evenly over the entire ocean.

About 200 ship-years would be needed to accomplish underway surveys of the entire ocean with ten-mile spacing between lines, but any of the combinations shown indicates how much might be expected to be accomplished by a given date with a limited number of ships.

| | 2 ships | 5 ships | 10 ships | 20 ships | 30 ships |
|---|---|---|---|---|---|
| 1963 | 103,680 n.m.<br>1011 l.s. | 259,200<br>404.4 | 518, 400<br>202.2 | 1,036,800<br>101.1 | 1,555,200<br>67.4 |
| 1964 | 207,360 n.m.<br>505.5 l.s. | 518,400<br>202.2 | 1,036,800<br>101.1 | 2,073,600<br>50.6 | 3,110,400<br>33.7 |
| 1965 | 311,040 n.m.<br>337 l.s. | 777,600<br>134.8 | 1,555,200<br>67.4 | 3,110,400<br>33.7 | 4,665,600<br>22.5 |
| 1966 | 414,720 n.m.<br>252.7 l.s. | 1,036,800<br>101.1 | 2,073,600<br>50.6 | 4,147,200<br>25.3 | 6,220,800<br>16.8 |
| 1967 | 518,400 n.m.<br>202.2 l.s. | 1,296,000<br>80.9 | 2,592,000<br>40.4 | 5,184,000<br>20.2 | 7,776,000<br>13.5 |
| 1968 | 622,080 n.m.<br>168.5 l.s. | 1,555,200<br>67.4 | 3,110,400<br>33.7 | 6,220,800<br>16.8 | 9,331,200<br>11.2 |
| 1969 | 725,760 n.m.<br>144.4 l.s. | 1,814,400<br>57.8 | 3,628,800<br>28.9 | 7,257,600<br>14.4 | 10,886,400<br>9.6 |
| 1970 | 829,440 n.m.<br>126.4 l.s. | 2,073,600<br>50.6 | 4,147,200<br>25.3 | 8,294,400<br>12.6 | 12,441,600<br>8.4 |
| 1971 | 933,120 n.m.<br>112.3 l.s. | 2,332,800<br>44.9 | 4,665,600<br>22.5 | 9,331,200<br>11.2 | 13,996,800<br>7.5 |
| 1972 | 1,036,800 n.m.<br>101.1 l.s. | 2,592,000<br>40.4 | 5,184,000<br>20.2 | 10,368,000<br>10.1 | 15,552,000<br>6.7 |

Top figure nautical miles steamed. Lower figure line spacing(nautical miles between trackline)

# APPENDIX IV

## OCEAN SURVEY PROGRAM FOR THE 1963 FIELD SEASON

The tentative Ocean Survey Program for the 1963 field season is presented here to provide an example of the types of operations which the Ocean Survey Plan includes. This program is subject to modifications which may result from the annual planning and review conference and from changes in operational requirements during the year.

### A. Cooperative International Programs

Detailed plans for the International Cooperative Investigations of the Tropical Atlantic (ICITA) and International Indian Ocean Expedition (IIOE) have been presented elsewhere and will not be repeated here. It is possible that a joint U.S.-Japanese program of underway surveys will be undertaken in the North Pacific starting late in 1963. This program, however, is still in the preliminary discussion stage.

### B. Pacific Ocean

The PIONEER (C&GS) will continue on Loran-C controlled ocean surveys in the North Pacific between the Hawaiian Islands and the Aleutians. Underway operations with PDR, magnetometer, gravity meter, surface water measurements, and meteorological observations will be carried out in the holiday area between 155°45'W and 159°W working north from Hawaii to about 45°N. Upon completion of work in this area

the Hawaii-to-Aleutian surveys will be extended westward. In the late spring a zigzag line of oceanographic stations is planned between the 155th and 160th meridians from Hawaii north. Some of the standard stations of the 1961 and 1962 operations will be repeated, and stations will be concentrated in the region of the boundary between the Sub-Arctic water and the North Pacific Central water. Subsurface currents will be investigated in this region with Swallow pingers and possibly with current meters from deep anchor stations. Bottom photographs will be made in the Aleutian Trench, the rise to the south of it, the abyssal plain, and the Hawaiian Rise to determine the visual changes in bottom characteristics across the region. Special water samples will be obtained for the National Institute of Oceanography in England. Details of the biological program (BF), coring program (GS), and radioactivity studies (SIO) have yet to be worked out. When the late summer weather makes gravity observations marginal, the area of underway operations will be shifted to the southern end of the region.

The SURVEYOR (C&GS) with Loran-C control will make several crossings of the Hawaiian Swell between Hawaii and Midway with PDR, magnetometer, gravity meter, and surface water measurements. She will continue these underway surveys between Midway and 45°N working eastward from the

180th meridian. A set of oceanographic stations along 180° will be occupied at the same time the PIONEER is occupying stations along 160 W. Her program after May will consist of underway ocean surveys south of the Aleutians and west of the PIONEER's area.

NORTHWIND (CG) on the annual Bering Sea Patrol will concentrate her physical and biological (BCF) operations in the Bowers Bank area (52-55°N). Her post-season operations will include oceanographic work in cooperation with Oregon State University and the University of Washington and seismic work in cooperation with the University of Wisconsin, Lamont Geological Observatory, and others. There is a possibility that this work might be extended into the Laptev and Kara Seas.

The MAURY and SERRANO (NOO) between January and May will be carrying out hydrographic and other oceanographic surveys in the Gulf of Siam to obtain information for nautical charts and sailing directions, and to supplement the existing oceanographic knowledge of the area. SERRANO will spend about half of this time in the Indian Ocean doing heat flow measurements, standard oceanographic stations, and chemical, biological, meteorological and sea and swell observations. In October the MAURY and SERRANO will conduct hydrographic surveys and limited additional oceanographic operations in the South China Sea, and en route

between there and Pearl Harbor. The REHOBOTH (NCO) will carry out oceanographic surveys in an, as yet, undetermined part of the Pacific to obtain environmental data for long range SONARS. Data will be collected on bottom reflectivity, bottom geologic structure and acoustic properties, bottom sediments and topography, plus observations and measurements with standard Nansen casts, sound velocimeter, and biological tows and trawls. Additional data will also be collected specifically for BuShips, but the exact nature and location of these data are not yet known.

C. ATLANTIC OCEAN

The SHELDRAKE and PREVAIL (NOO) will be alternated between hydrographic-acoustic surveys in the Bahamas and hydrographic-oceanographic surveys off the east coast of the United States. These latter surveys are directed towards filling holiday areas in the region west of a line between Newfoundland and the Barbados. The exact dates and areas of these surveys are not yet firm, but these operations will not be commenced until after the first of June.

The LITTLEHALES (NOO) will conduct four surveys in the Bahamas area. On two of them, she will investigate (1) sound propagation conditions at selected locations and collect acoustic data on ambient noise variations as functions of sea state, depth, and wind speed, (2) diurnal variations in ambient noise from time-series stations, and

(3) rate of decay of ambient noise from shallow to deep water. On the other two surveys, the LITTLEHALES will conduct shallow-water current studies along the east coast of Andros Island and on the shallow banks between Tongue of the Ocean and Exuma Sound.

The TANNER and REQUISITE (NOO) will run hydrographic surveys in the Windward Passage. About 360 ship-days will be required. Position control will be by LORAC. When LORAC reception is poor (during several hours each night in this area) oceanographic observations will be made in the Windward Passage area.

The SAN PABLO (NOO) will be running oceanographic surveys to collect environmental data for long-range SONARS. The area of Atlantic operation has not been finally determined, but data will be obtained on bottom reflectivity, bottom geologic structure and acoustic properties, bottom sediments and topography, plus observations and measurements with standard Nansen casts, sound velocimeters, and biological tows and trawls.

The Coast Guard Cutter CASCO has been equipped for oceanographic operations and will make pilot trips in the North Atlantic starting in late January while assigned to Ocean Station Echo (35°00'N, 48°00'W) and continued on Ocean Station Delta (44°00'N, 41°00'W) in April. Based on these trial runs on the CASCO, additional outfitting of

eight Ocean Station vessels will be undertaken and is expected to be completed by July of 1964.

The EVERGREEN (CG) will continue International Ice Patrol surveys in the northwest North Atlantic. Special oceanographic surveys will be undertaken in Baffin Bay and the Laborador Sea at the request of the International Commission for the Northwest Atlantic Fisheries (ICNAF). These will involve standard oceanographic sections plus plankton and productivity studies. Ocean Station Bravo (56°30'N, 51°00'W) will be specially equipped for surface water physical measurements and for collecting plankton during these ICNAF surveys.

Additional Coast Guard oceanographic survey operations may be carried out from an icebreaker in the East Greenland Sea, and a Coast Guard Cutter will take part in EQUALANT II of ICITA.

After taking part in EQUALANT I of ICITA in February-April, the EXPLORER (C&GS) will carry out hydrographic surveys around Puerto Rico. In July she commences Raydist-controlled combined hydrographic, magnetic, and other oceanographic surveys off Cape Hatteras. Included will be current measurements, standard oceanographic stations, and bottom photography. The ship will also carry out bottom biological observations in cooperation with the Duke University Marine Laboratory and bottom sediment sampling in cooperation with

the Geological Survey. Detailed plans for this survey are still in the formative stages.

The PEIRCE (C&GS), a new 760-ton survey vessel, will complete her shakedown in March, and from April through September will be running Raydist-controlled offshore surveys working south from Cape Romain (33°N). She will carry out detailed hydrographic, magnetic, and sub-bottom acoustic surveys plus bottom sediment and current studies over the area between the 10-fathom and 100-fathom depth contours. Standard oceanographic sections will be made normal to the coast. This survey is the part of the Coast and Geodetic Survey's continuing program of east coast offshore comprehensive surveys. Other east coast and gulf coast surveys by ships of this bureau are primarily for nautical charting.

The Woods Hole Oceanographic Institution working in conjunction with the Geological Survey will in 1963 commence a marine geological survey of the east coast shelf and slope, working south from Cape Hatteras. Position control will be by Loran-C with line spacing at 10 miles on the shelf and 30 to 60 miles on the slope and seaward. Field work will include profiles of bottom topography, magnetics, and sediment thickness plus sediment and rock sampling and such biological and physical data as may be important in interpreting the geological data. Plans for this survey are being coordinated with those of the Coast and Geodetic Survey.

Scientists and technicians from the Weather Bureau, Geological Survey, and Bureau of Commercial Fisheries will participate in many of these survey operations during 1963. Programs of private oceanographic institutions and of universities without ship facilities will be accommodated whenever possible. These plans are presented as they currently stand (December 1962). There will, however, be some changes and additions as the various surveys are modified by operational requirements and as a result of additional discussions with the general oceanographic community.

Interagency Committee on Oceanography

AUTHOR

NATIONAL PLAN FOR OCEAN SURVEYS.

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